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**LEASIDE TS TO CHERRYWOOD TS**
**230 kV FOUNDATION INVESTIGATION**

H.S. Radhakrishna

In situ pressuremeter tests were performed at eight selected tower sites along the proposed new steel pole line between Sheppard TS to Cherrywood TS. From these tests the deformation modulus of different soil types encountered along the line were determined. The results are reported and the nature of correlations between the initial loading modulus, $E_1$, and the standard penetration value, N, are examined for both granular and cohesive soils.

## INTRODUCTION

A geotechnical investigation was performed for the proposed new steel pole line along the transmission corridor from Sheppard TS to Cherrywood TS. An estimate of the deformation modulus, E, or subgrade reaction, Ks, is required for the design of steel pole foundations. The pressuremeter tests were performed at eight tower sites representing the different soil conditions encountered along this route. The results of the pressuremeter tests and their correlation with the standard penetration values are presented.

## TEST PROGRAM

The pressuremeter test consists of inserting an NX-sized probe in a predrilled test hole and stressing the borehole wall by applying a pressure in increments. The radial deformation of the test hole is measured by recording the probe volume change. Figures 1 to 3 show the typical pressure volume change curves from the pressuremeter tests in soft clay, compact silty sand, and dense sand and gravel. The test data was corrected to account for (i) the influence of the membrane inertia and (ii) the differential hydrostatic pressures acting on the probe while performing the pressuremeter test.

The following parameters were calculated from the pressuremeter test data and are summarized in Table I:

(a) initial loading deformation modulus, $E_1$ (MPa)
(b) reloading deformation modulus, $E_R$ (MPa)
(c) yield pressure of soil, $P_y$ (MPa)

## SOIL CONDITIONS

The primary soil type encountered in this portion of the transmission corridor was a dense to very dense glacial deposit consisting of silty sand with variable proportions of gravel. At Towers 91, 93, 108 and 119, layers of loose to compact sand and soft to firm clay were encountered. Tower 108 was located in a poorly drained area where high groundwater levels and caving conditions were encountered. The pressuremeter tests at this tower location were affected by the caving conditions. These tests were repeated by using drilling mud to form the test holes.

The glacial till deposit encountered at Towers 111 and 115 was in an extremely dense state (N values in excess of 100 blows/0.3 m).

## TEST RESULTS

The pressuremeter moduli ($E_1$) ranged from 3 to 50 MPa for granular soils. $E_1$ values in the range of 50 to 100 MPa were measured in very dense till layers. The clay layers encountered in a number of boreholes had a soft to firm consistency with $E_1$ values ranging from 2 to 10 MPa.

A correlation between $E_1$ and a standard penetration value N was attempted for granular soils by combining the data obtained from this investigation to the earlier data base/1,2 and 3/. Figure 4 shows the trend in the relationship between the deformation modulus $E_1$ and the standard penetration value N for granular soils. The best fit for the combined data was obtained with a linear regression in a log-log plot. The equation for the regression line is:

$$E_1 = 1.15\ (N)^{0.75}.$$

where $E_1$ is the deformation modulus (MPa)
N is the standard penetration value (blows/0.3 m)

A considerable scatter in the data is present over the full range of soil consistency. The data obtained from this investigation generally falls above the regression lines. Therefore, the proposed correlation can be used with confidence. For the cohesive soils, the new data was very limited and therefore no correlation was attempted between the deformation modulus and the shear strength.

For the dense to very dense till layers, no useful correlation between $E_1$ and N was possible due to the non-validity of the standard penetration values. The regression line obtained for the granular soil data largely underestimates the deformation modulus $E_1$ for very dense till. Therefore, it is recommended that the measured values of the pressuremeter modulus $E_1$ be used directly in the design of pole foundations for this line.

## CONCLUSIONS

The soil conditions encountered along the proposed steel pole line are characterized by the glacial till deposits with interbedding of lacustrine clay and silt beds. A wide range of pressuremeter modulus values were obtained depending on the consistency of the soil as measured by the standard penetration value. Based on the combined data, correlation functions between E and N were obtained for the granular soils.

This correlation function should be used only as a guide for selecting the deformation modulus for the subject line. For cohesive soils, not enough data is available to develop a new correlation. For the dense to very dense glacial till deposit, the measured values of deformation modulus should be used as there is no valid correlation with the N values.

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## REFERENCES


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TABLE I
CHERRYWOOD SS TO LEASIDE TS TOWER LINE
PRESSUREMETER TEST RESULTS

| TOWER # | DEPTH (m) | SOIL DESCRIPTION | SPT (N) BLOWS/0.3 m | PRESSUREMETER TEST RESULTS | | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | $E_I$ (MPa) | $E_R$ (MPa) | $P_Y$ (MPa) | |
| 91N | 1.0 | compact silty sand with some clay | 20 | 12.2 | 17.6 | 0.8 | |
| | 2.1 | dense sand and gravel | 70 | 33.9 | 114.0 | 3.5 | |
| | 3.0 | compact silty sand | 17 | 17.9 | 31.9 | 1.2 | |
| | 4.1 | firm silty clay | - | 4.7 | 11.5 | 0.6 | |
| | 5.3 | compact silty sand | 16 | 12.0 | 16.5 | 0.7 | |
| | 6.1 | very dense silty sand and gravel | 100 | 43.0 | 97.0 | 4.8 | |
| | 7.0 | very dense silty sand and gravel | >117 | 39.4 | 109.0 | 4.5 | |
| 93N | 1.0 | dense sand and gravel | 57 | 17.0 | 70.0 | 1.0 | |
| | 2.1 | dense sand and gravel | 49 | 21.0 | 65.0 | 1.0 | |
| | 3.0 | compact sandy silt | 29 | 10.3 | 15.0 | 0.8 | |
| | 4.1 | very dense silty sand and gravel | 103 | 30.0 | 78.0 | 3.0 | |
| | 5.2 | firm clay | 10 | 9.0 | 18.0 | 0.6 | |
| | 6.1 | firm clay | - | 7.0 | 16.0 | 0.5 | |
| | 7.2 | firm clay | - | 8.0 | 12.0 | 0.6 | |
| | 8.2 | firm clay | 11 | 5.0 | 11.0 | 0.5 | |
| | 9.8 | stiff clayey silt | - | 9.0 | 16.0 | 1.0 | |

TABLE I (cont'd)
CHERRYWOOD SS TO LEASIDE TS TOWER LINE
PRESSUREMETER TEST RESULTS

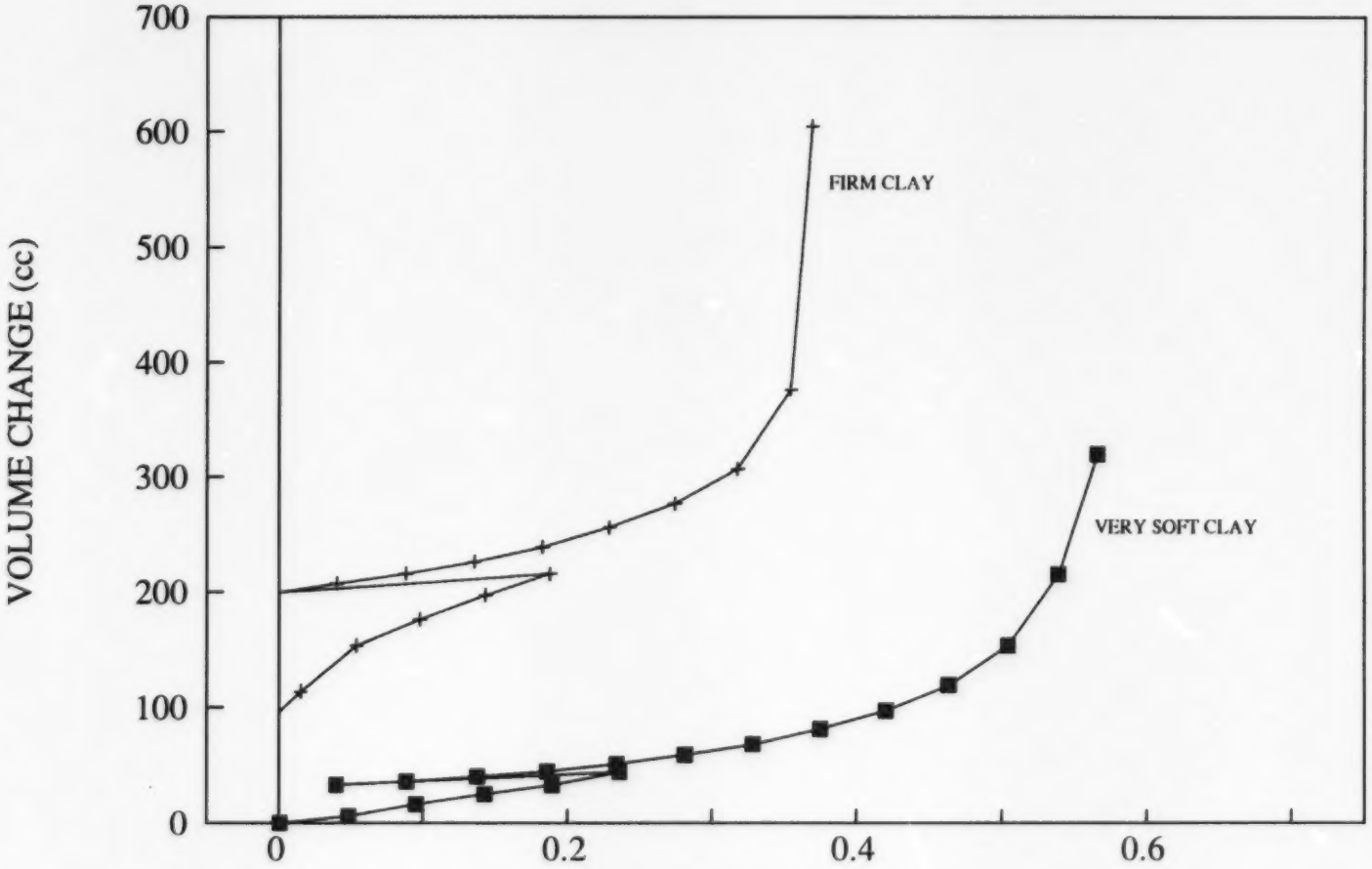
| TOWER # | DEPTH (m) | SOIL DESCRIPTION | SPT (N) BLOWS/0.3 m | PRESSUREMETER TEST RESULTS | | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | $E_I$ (MPa) | $E_R$ (MPa) | $P_Y$ (MPa) | |
| 98N | 1.0 | very dense sand and gravel | 88 | 18.0 | 28.0 | 1.0 | |
| | 3.0 | very dense sand and gravel | 81 | 29.0 | 69.0 | 3.0 | |
| | 3.8 | compact wet sand | 27 | 17.0 | 24.0 | 1.0 | |
| | 7.4 | very soft clay | 3 | 2.0 | 5.0 | 0.4 | |
| | 9.1 | very soft clay | - | 3.0 | 7.0 | 0.3 | |
| | 10.6 | soft clayey silt | 7 | 4.0 | 9.0 | 0.4 | |
| | 12.2 | soft clayey silt | 12 | 5.0 | 9.0 | 0.5 | |
| 104 | 1.0 | compact sand and silt | 19 | 16.6 | 16.8 | 1.2 | |
| | 2.0 | compact sand and silt | 17 | 233.0 | 82.3 | 2.8 | |
| | 2.7 | dense sand and gravel, some cobble | 35 | 34.2 | 53.6 | 3.2 | |
| | 3.9 | compact silty sand | 28 | 11.2 | 17.1 | 2.1 | |
| | 5.1 | very dense sand and gravel | 54 | 31.0 | 58.4 | 3.5 | |
| | 6.9 | very dense sand and gravel | >85 | 30.2 | - | 3.7 | |

TABLE I (cont'd)
CHERRYWOOD SS TO LEASIDE TS TOWER LINE
PRESSUREMETER TEST RESULTS

| TOWER # | DEPTH (m) | SOIL DESCRIPTION | SPT (N) BLOWS/0.3 m | PRESSUREMETER TEST RESULTS | | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | $E_I$ (MPa) | $E_R$ (MPa) | $P_Y$ (MPa) | |
| 108N | 1.0 | dense silty sand and gravel | 27 | 6.5 | 13.1 | 0.7 | |
| | 1.7 | dense silty sand and gravel | 28 | 9.4 | 20.0 | 1.6 | |
| | 2.5 | dense silty sand with some gravel | 50 | 28.4 | 63.0 | 2.5 | |
| | 4.2 | compact wet silty sand | 14 | 11.3 | 16.5 | 1.0 | |
| | 5.1 | compact wet silty sand | 21 | 14.5 | 39.8 | 1.0 | |
| | 6.0 | compact wet silty sand | 29 | 15.3 | 29.5 | 1.3 | |
| | 7.1 | compact wet sandy silt | 23 | 15.7 | 23.6 | 1.3 | |
| | 8.0 | loose wet sandy silt | 7 | - | - | - | caving - no test |
| 111N | 1.0 | soft silty clay | - | - | - | - | hole oversized -no test |
| | 2.0 | extremely dense silty sand and gravel (glacial till) | 106 | 105 | 141 | >6 | |
| | 3.0 | as above | >100 | 85 | 121 | >7 | |
| | 4.0 | as above | >100 | 151 | 163 | >6 | |
| | 6.2 | as above | >100 | 260 | 435 | >7 | |
| | 8.0 | as above | >100 | 249 | 370 | >7 | |

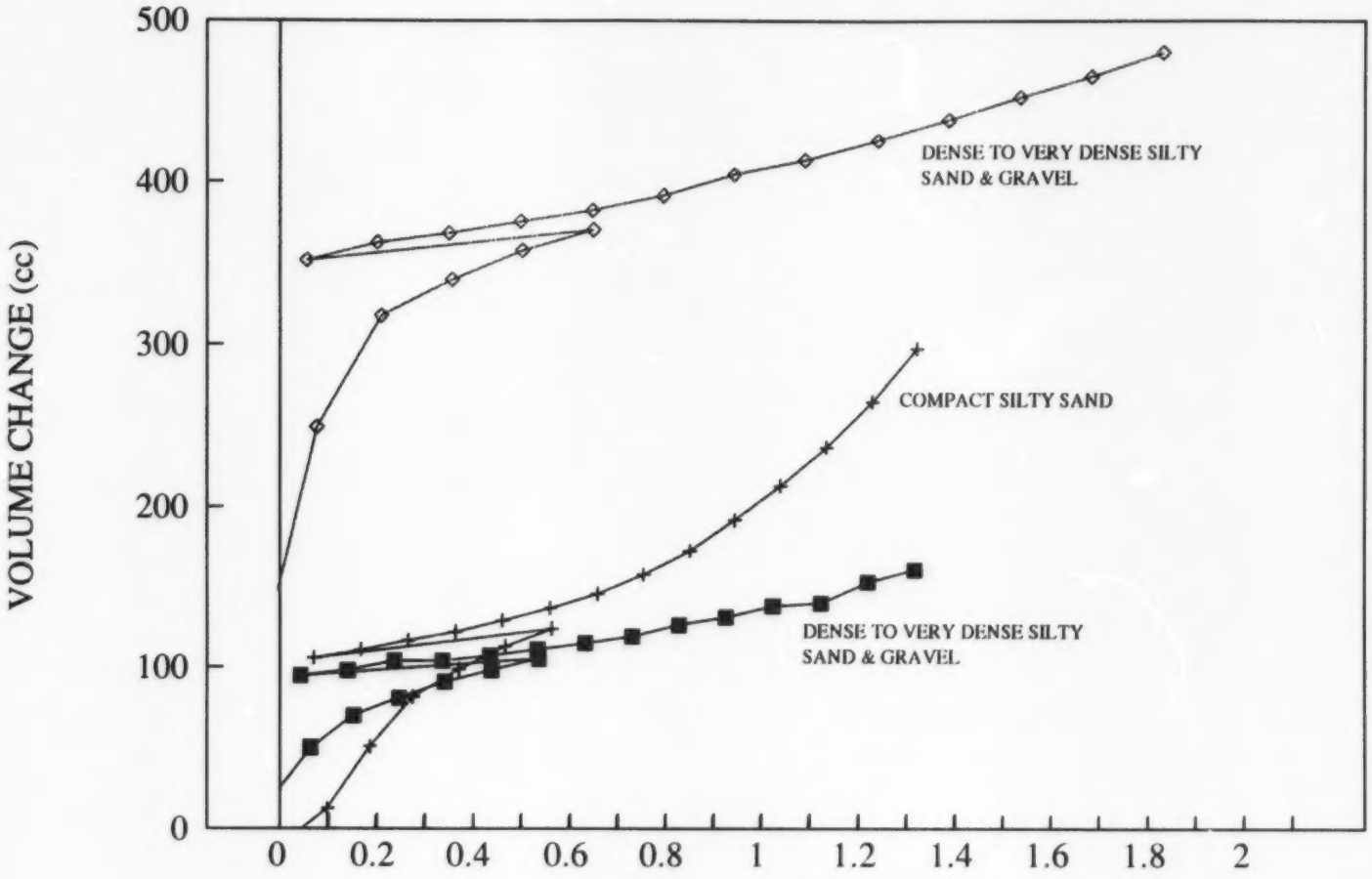
TABLE I (cont'd)
CHERRYWOOD SS TO LEASIDE TS TOWER LINE
PRESSUREMETER TEST RESULTS

| TOWER # | DEPTH (m) | SOIL DESCRIPTION | SPT (N) BLOWS/0.3 m | PRESSUREMETER TEST RESULTS | | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | | $E_I$ (MPa) | $E_R$ (MPa) | $P_y$ (MPa) | |
| 115N | 1.0 | compact sandy silt | 25 | 14.6 | 38.1 | 1.5 | |
| | 2.1 | compact sandy silt | 27 | 23.6 | 111.0 | 1.6 | |
| | 3.0 | extremely dense sandy silt with gravel (glacial till) | 103 | 97.5 | 239.0 | 6.0 | |
| | 4.1 | as above | >83 | 63.2 | 158.0 | 5.8 | |
| | 5.1 | as above | 135 | 93.5 | 201.0 | 6.5 | |
| | 6.1 | as above | 108 | 48.9 | 102.0 | 6.0 | |
| | 7.0 | as above | 96 | 54.8 | 175.0 | 6.7 | |
| | 9.7 | as above | 63 | 103.0 | 277.0 | 6.8 | |
| 119N | 1.0 | loose dry sand | 8 | 11.0 | 13.6 | 0.6 | |
| | 3.0 | dense silty sand | 53 | 21.0 | 92.0 | 2.0 | |
| | 3.8 | dense saturated sand | 53 | 26.3 | 125.0 | 2.2 | |
| | 4.9 | very dense fine sand | 59 | 23.0 | 98.6 | 3.3 | |
| | 6.1 | very dense fine sand | 73 | 18.5 | 68.3 | 2.6 | |
| | 7.6 | compact wet sand | 36 | 19.0 | 35.4 | 1.8 | |
| | 8.5 | firm sandy clay | 14 | 5.9 | 15.4 | 0.8 | |
| | 9.4 | firm sandy clay | - | 8.6 | - | 0.7 | |



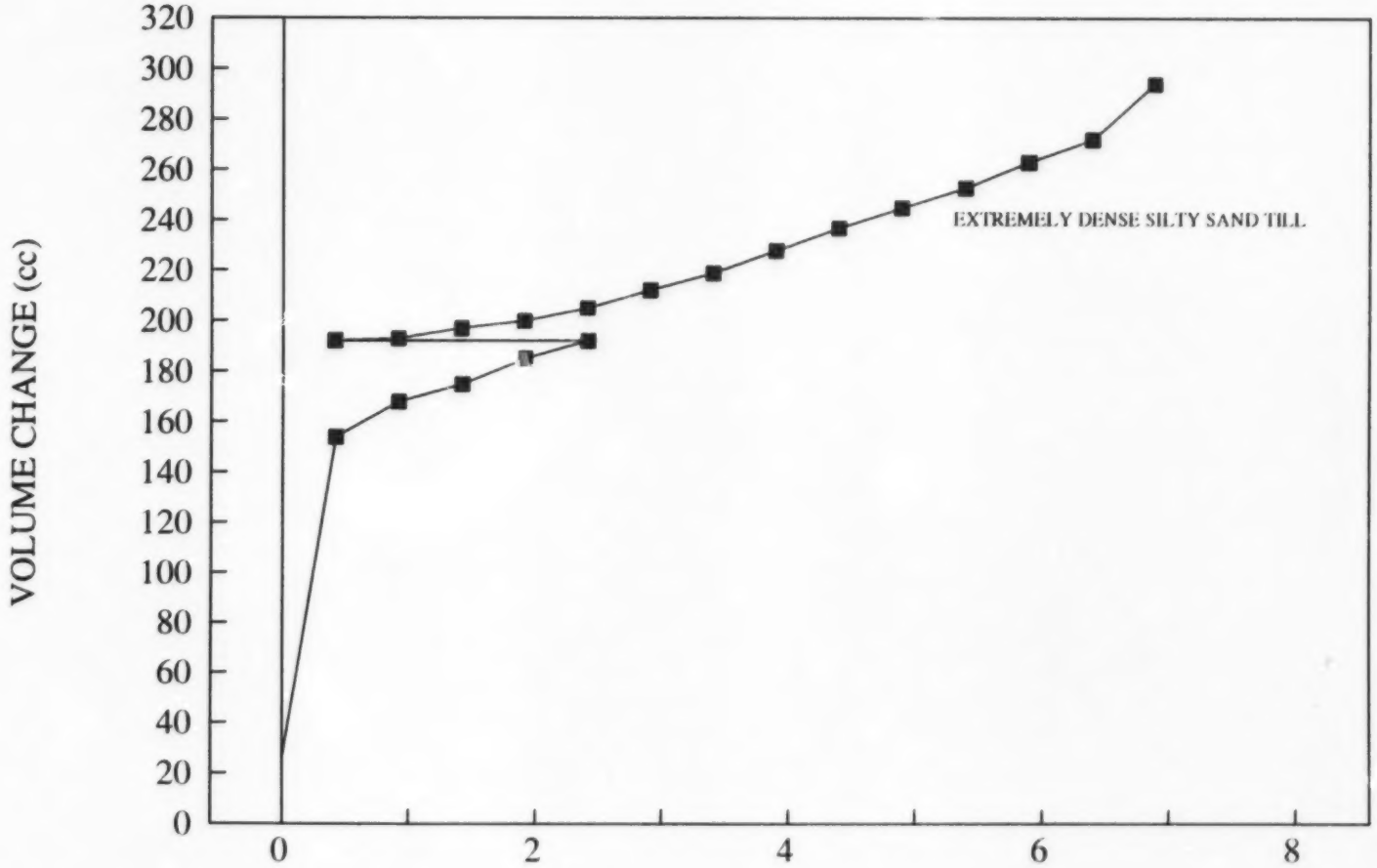

**CHERRYWOOD-LEASIDE PRESSUREMETER TEST**

FIGURE 1




**CHERRYWOOD-LEASIDE PRESSUREMETER TEST**

FIGURE 2




**CHERRYWOOD-LEASIDE PRESSUREMETER TEST**

FIGURE 3

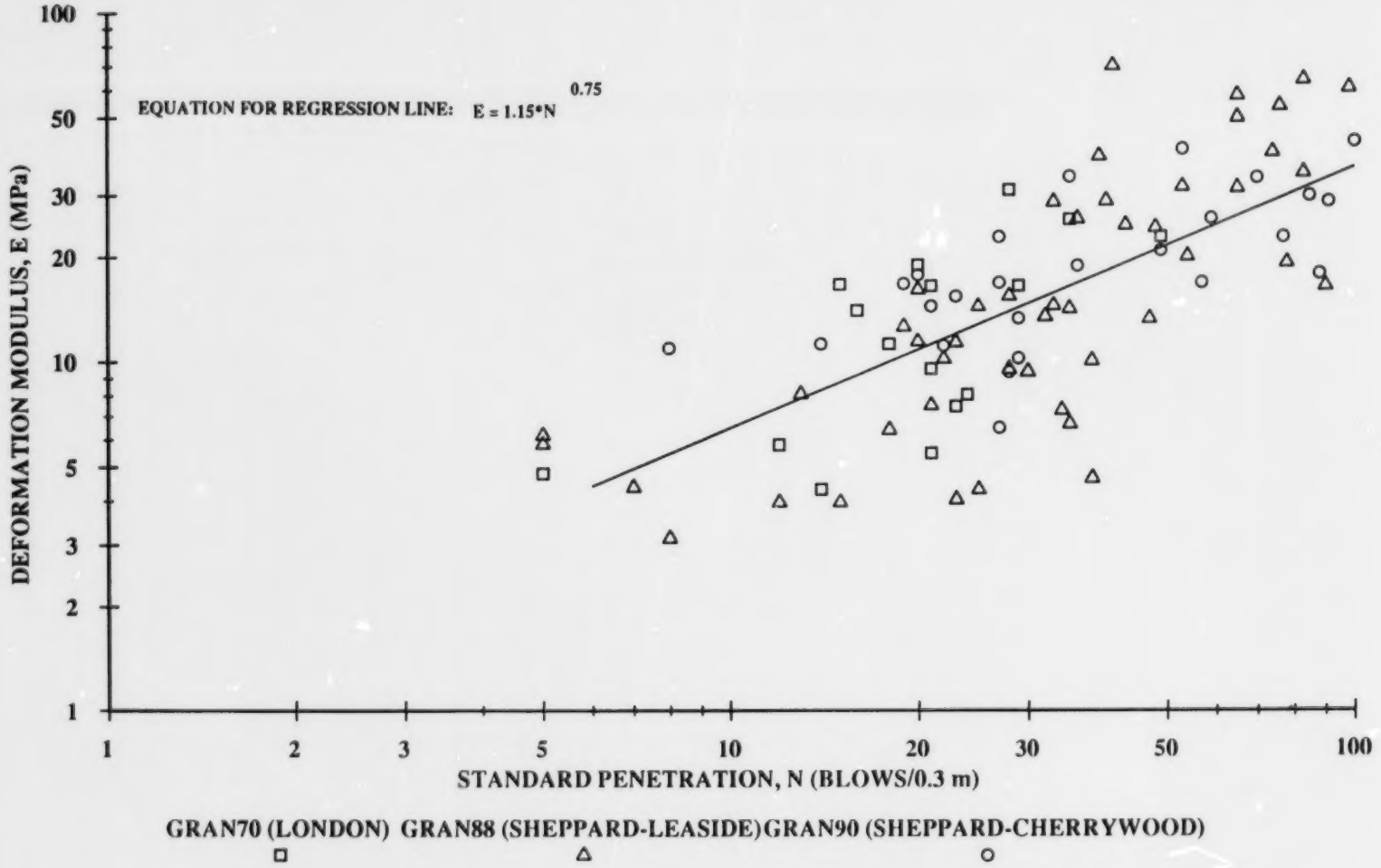



**FIGURE 4**

**DEFORMATION MODULUS vs STANDARD PENETRATION FOR GRANULAR SOIL**